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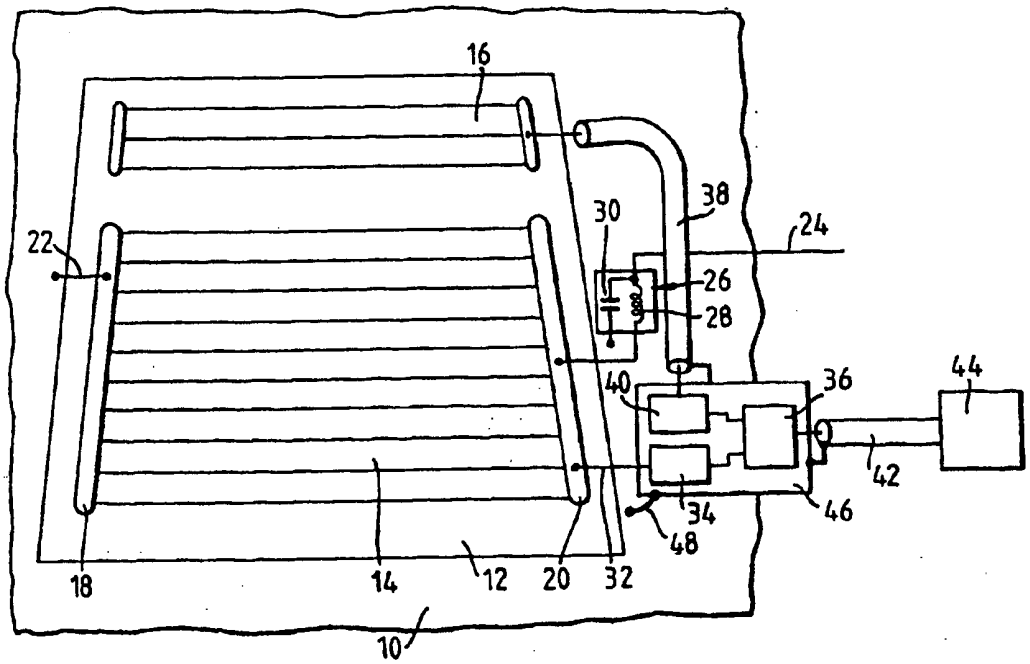

(57) Abstract

An antenna for fitting to a vehicle comprising a sheet forming a window of the vehicle; a plurality of resistive conductors (14) interconnected by bus-bars (18, 20) which receive heater current (24); and a ground connection (22) and a VHF tapping connection (32) positioned to effect optimum omni-directional VHF signal reception. In another embodiment of the invention the signals from an AM and an FM section of the antenna are combined by an on-glass module containing respective amplifiers and a combiner.

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VEHICLE ANTENNA

This invention relates to a window antenna, most usually a rear window antenna for a motor vehicle such as a motor car, van or goods vehicle.

Rod antennas are the most usual means of collecting broadcast AM and FM signals in road vehicles. However, they suffer from a number of disadvantages. They are prone to be vandalised, or damaged in a car wash. They can be unsightly and can pose a safety hazard. They require an opening in the vehicle bodywork which can give rise to water leakage and/or corrosion. They increase vehicle aerodynamic drag.

Window antennas for motor vehicles have been known at least since the 1940's - see DE-A-730131 (Immendorf). Such antennas can consist, in effect, of a plate on a window of the vehicle, connected by a lead to the vehicle radio. In this form, the plate, which could be replaced by an array of conductors defining a skeleton form thereof, acts in the same way as a rod antenna, but is enclosed within the envelope shape of the vehicle.

There have been many attempts to use heating elements of a rear screen of a vehicle simultaneously as an antenna at both AM and FM frequencies e.g US-A-3484584 (Shaw) and GB-A-1520030 (Kropielnicki et al). These make use of large inductive chokes, which are bulky, heavy and costly, to isolate the screen from the vehicle ground at radio frequencies. The heating elements thus form an antenna which is effectively the same as the plate described above. Shaw suggests that chokes may not be necessary for use of the heated screen as an antenna at VHF FM frequencies.

In another form, disclosed in US-A-2923813 (Davis), a wire or a plate across the glass is used, one side of which is connected to the vehicle ground. Broadcast signals induce circulating currents in the metal body shell of the vehicle. The window opening provides a discontinuity in this shell, and a voltage difference appears between opposite sides of this opening. If the ungrounded side of the wire or plate is connected to a radio receiver, these voltages are transferred to the radio, thus providing reception of the broadcast signals. This form of antenna has been found to be suitable for

use at VHF frequencies, but inefficient at low frequencies, such as the AM broadcast band.

In US-A-4439771 (priority 15 May 1981 JP 72913/81 Kume et al) it is accepted that a heated, conductor-bearing region, and a separate unheated conductor-bearing region of the glass may be used in combination to provide reception of AM and FM signals. Kume extends this idea, and describes a diversity antenna system.

An ideal vehicle antenna will have an omnidirectional polar reception characteristic i.e the received signal strength being equal no matter in which direction the vehicle is facing relative to the transmitter. Most antennas fitted to vehicles are deficient in this respect, in particular at VHF frequencies such as are used by FM broadcast stations, which can result in disturbing changes in audio level, loss of stereo image, noise and distortion.

The object of the present invention is to provide a window antenna on a vehicle such that there is insignificant variation in received signal strength as the vehicle is rotated.

We have found that the polar distribution of signals from an antenna of the type described by Davis, which may be formed partly by the array of conductors used to heat a rear screen, varies according to the position of the FM signal takeoff, or tapping point on one bus-bar, and the position of the ground point along the opposite bus-bar.

The polar distribution can vary significantly between one model of vehicle and another, and between a saloon and a hatchback version of the same model, as well as between different manufacturers' vehicles. This difference between vehicle types is not surprising, since the metal bodyshell of the vehicle forms an integral part of the antenna. Antennas of this type have also been found to be frequency dependent, so that an arrangement which works well at one frequency may perform poorly at another.

We have also found that symmetrical arrangements of tapping and grounding points do not give symmetrical polar responses as might be expected. Also, transposing the tapping point and ground point does not produce similar results.

The arrangement which produces the most omnidirectional performance across the VHF range must therefore be determined by actual trial for each vehicle model and/or variant.

The present invention provides, in one aspect, a window antenna for fitting to a predetermined model of vehicle and comprising:

a sheet of glass forming the rear window of the vehicle, the sheet of glass usually having a width greater than its height;

an array of resistive conductors directed generally parallel to the longitudinal or side to side direction of the glass sheet and interconnected at their ends by bus-bars which receive heater current via respective live and ground connections;

a connection on one of the bus-bars for supply of very high frequency radio signals from the antenna, the position of the ground connection and the position of the connection by which the very high frequency signal is supplied being on opposite bus-bars and being positioned such that there is an insignificant variation in received

signal strength as the vehicle is rotated for signals in the FM broadcast band.

In a further aspect the invention provides an antenna for fitting to a vehicle, comprising a sheet of glass for forming a window of the vehicle, a first array of resistive conductors on the sheet interconnected at their ends by bus-bars which receive heater current via respective live and ground connecting lines and have a connecting line from one of the bus-bars for the supply of FM signals, a second array of conductors on the sheet having a connecting line on the same side as the VHF connection to the first array for the supply of an AM radio signal, the connecting line for the supply of FM signals being located adjacent an end of bus-bar to which it is connected which is nearer to the second array of conductors.

In a yet further aspect, the invention provides an antenna for fitting to a vehicle, comprising a sheet of glass for forming a window of the vehicle, a first array of resistive conductors on the sheet interconnected at their ends by bus-bar which receive heater current via respective live and ground connecting lines and having a

connecting line from one of the bus bars for the supply of FM radio signals, a second array of conductors on the sheet having a connecting line for supplying an AM signal, the AM and FM connecting lines passing on the surface of the sheet of glass to a module thereon which incorporates respective amplifiers and a combiner, a connecting line leading from the module out of the glass sheet for establishing an RF connection to a radio.

Preferably in the antenna assembly as aforesaid, the module is arranged to receive DC power via the RF connecting line. DC power may also be provided via the RF connecting line in other forms of the invention where the module is not located on the glass.

Embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

FIG 1 is a diagrammatic representation of a rear window having a combined heater and antenna thereon, and the associated circuits;

FIG 2 is a diagrammatic representation of a rear window glass, showing an example of a number of test

points positioned along the length of the bus-bars which may be used to evaluate the directional characteristic of the FM antenna;

FIGS 3, 4 and 5 are polar graphs showing the received signal strength as a vehicle is rotated at four frequencies for firstly the VHF part of the antenna of FIG 1 at a non-optimised configuration, secondly for the same antenna at an optimised configuration, and thirdly for a rear fender mounted vertical rod antenna as supplied with the vehicle; and

FIGS 6 and 7 show further forms of the invention.

In FIG 1, an aperture in the vehicle's metal bodyshell 10 contains a rear window 12 on which are a first array of conductors 14 defining a heated area and part of an FM antenna, and a second unheated area 16 shown above, but may be below, the first area and electrically unconnected thereto, the second area 16 serving as an antenna for AM reception. The conductors 14 are connected at their ends by bus-bars 18,20 which are clear of the surrounding metal bodyshell to prevent attenuation of the received signal. Area 16 is likewise clear of the metal bodyshell for the same reason. The conductors defining the areas 14, 16 and the bus-bars 18, 20 as well as the leads

32, 33 may be formed by printing appropriate inks onto the glass panel 12 at the time when the screen is being manufactured. A clearance of about 30mm is usually appropriate. The clearance may however be even less than this, typically about 20mm and in practice very close to the surrounding vehicle metalwork. It is an advantage of the invention that the ends of the conductors defining areas 14 and 16 may be located very close to the metalwork where it overlies the glass of the window pane. The bus-bar 18 is connected to ground at 22 and the bus-bar 20 is connected to the heater DC power line 24. The heater power line 24 may contain a filter 26 consisting of, for example, an inductor 28 and a grounded capacitor 30. The filter 26 attenuates noise from the electrical system of the vehicle and isolates the conductors 14 from the power line at VHF frequencies. The VHF signal from the antenna partly formed by conductors 14 is fed via a line 32 to an amplifier 34, and thence to a combiner 36. This combiner 36 also receives AM signals from antenna 16 via a line 38 and impedance matching amplifier 40. The output from a combiner 36 passes via a coaxial line 42 to the vehicle radio 44.

The amplifiers 34,40 should have a high output capability and also a band-pass characteristic in order to minimise the risks of intermodulation distortion due to strong signals inside and outside the required frequency ranges respectively.

It is desirable, in the case of a module 46 containing amplifiers 34,40 and combiner 36 being located some distance from AM antenna 16, that lead 38 be coaxial to avoid interference pickup, and preferably with a low value of capacitance per metre in order to reduce signal attenuation. Module 46 is preferably located close to the tapping point on the appropriate bus-bar, which may be determined by the method prescribed below, such that line 32 is as short as possible. The ground connection line 48 for module 46 is connected to the metal body of the vehicle, also by as short a path as possible.

The positions at which ground lead 22 and VHF signal lead 32 are connected to their respective bus-bars may be determined by the following method.

For each vehicle model, test points at intervals along the lengths of the bus-bars 18,20 are used for connection to ground and to VHF signal line 32. By way of illustration, FIG 2 shows a number of test points (marked A,B,C,D,E) along the length of bus-bar 18, and a further number of test points (marked A',B',C',D',E') along the length of the opposite bus-bar 20. In the example shown, there are therefore a total of fifty permutations of VHF tapping point and ground point i.e twenty-five with the ground point along bus-bar 18 and with VHF tapping point along bus-bar 20, and twenty-five with these connections reversed.

The vehicle is placed on a turntable at a suitable test site and rotated through 360 degrees for each permutation of points, and for a number of test frequencies across the VHF broadcast band, the relative signal strength received by each configuration is measured by angular increments. The results thus obtained may be plotted in the form shown in FIGS 3, 4 and 5. An undesirable result as shown in FIG 3 has deep nulls at the 89.5 and 99.1 MHz test frequencies. By contrast, a desirable result indicating an optimised pair of ground and tapping positions, is shown in FIG 4. This is generally free of

nulls at any angular position or at any of the test frequencies. Any variability in the signal level can thus be compensated for by automatic gain control circuits which are usually incorporated in the vehicle's radio receiver. This will result in a perceived steady level of sound and freedom from noise or distortion.

In order to achieve the best omnidirectional performance from the antenna system, it may be necessary to perform subsequent tests, using a further set of test points along the bus-bars in the regions which have so far produced the most promising results. If, for example, the results showed reasonable polar responses with the VHF tapping point on bus-bar 18 at B and C, as shown in FIG 2, and with the grounding point on bus-bar 20 at D' or E', further sets of test points should be established e.g tapping point test points b1,b2 on bus-bar 18, and ground test points d1' and d2' on bus-bar 20.

Repeated sub-division of the length of the bus-bars in this manner, with further testing and result analysis will ultimately yield optimum tapping and ground positions.

Figure 6 shows an alternative embodiment of the invention in which the VHF-conductor 32 is connected to the bus bar 20 at an end thereof which is adjacent to the area 16. The conductors 32 and 33 emerge from the same side of the glass pane 12 in close proximity to one another and are connected by short current paths to the module 46. Signals from the module 46 pass by coaxial cable 42 to the radio 34 and power is fed to the module 46 from the radio 44 via a power line 43A. The remaining parts of the aerial system are as previously described.

In figure 7 the location where the VHF-conductor arises on the bus bar 20 is as previously stated, and the VHF- and AM-conductors 32a, 33 are connected to an on-glass module 46a having an output line 47 of coaxial cable which leads to connector 49, one side of which is connected to earth via line 48 and the second side of which is connected to a coaxial cable 42a leading to the radio 44. The cable 42a has built into it a line power tap 51 at which a branch connection 53 having an in line choke 55 leads to a power socket of the radio 44. The inner conductor of the cable 42a thereby provides the module 46a with its power, and the choke 55 in the DC power line 53 prevents loss of signal into the radio

through the line 53. A DC blocking capacitor may be incorporated between the line 42a and the RF socket of the radio, being located at the radio end of the coaxial cable 42a either inside a connector for establishing the RF connection to the radio 44 or being located in the tap 51. Alternatively the choke 55 and the blocking capacitor could be incorporated into the radio 44 by the manufacture thereof. By mounting the module 46a on the glass and supplying it with power via the coaxial cable 42a which feeds the RF signals to the radio, the number of wire connections to the module 46a is significantly reduced and installation thereof is simplified. The module 46a can be glued to the glass and can be provided on its blind face with contacts (e.g. spring connectors) for making contact with the conductors 32a, 33. As previously described, the locations of the earthing point 32 and the tapping point 33a along the bus bars 18, 20 is selected to give the best overall pattern of FM reception.

CLAIMS

1. An antenna for fitting to a vehicle comprising:

a sheet of glass for forming the rear window of the vehicle;

an array of resistive conductors directed generally parallel to the side to side direction of the said glass sheet and interconnected at their ends by bus-bars which receive heater current via respective live and ground connections; and

a connection on one of the said bus-bars for supply of very high frequency radio signals from the said antenna, the position of the ground connection and the position of the connection by which the very high frequency signal is supplied being on opposite bus-bars and being positioned such that there is an insignificant variation in received signal strength as the said vehicle is rotated for signals in the VHF broadcast band.

2. A method for determing the positions of the ground and VHF tapping points of an antenna for a vehicle window comprising the steps of:

(a) locating the said antenna in its use position;

(b) measuring the VHF signals received by said the antenna; and

(c) determining the said tapping points with regard to the stability of the said VHF signals received.

3. A method according to claim 2, in which the said measuring step is conducted for each of a plurality of pairs of the said positions, each pair of the said positions comprising a position for connection of the ground tapping point and a position for connection of the VHF tapping point, and

the said determining step comprises the steps of comparing the results of the said measuring step for different said pairs of positions.

4. A method according to claim 2 or claim 3, in which the said measuring step is measuring received VHF signals at a plurality of different frequencies, and

the said determining step comprises comparing the results of the measuring step for the said different VHF signal frequencies.

5. A method according to any of claims 2 to 4, in which the said measuring step comprises measuring the said received signal at a plurality of angular positions of the antenna relative to the VHF signal source.

6. A method according to any one of claims 2 to 5, in which the said determining step is conducted to avoid determining the tapping points which have the most unstable VHF signal reception.

7. A method according to any one of claims 2 to 6, in which the said determining step is conducted to avoid determining the tapping points which have nulls in the said VHF signal reception.

8. A method of providing a vehicle with a window antenna comprising:

providing a sheet of material forming a window of the said vehicle having an array of resistive conductors interconnected by bus-bars for receiving heater current, and attached to the said bus-bars, a ground connection and a VHF signal connection, wherein the said connections are provided at points previously determined to avoid an unstable VHF signal reception for the said vehicle.

9. An antenna for fitting to a vehicle comprising:

a sheet forming a window of the vehicle;

a plurality of resistive conductors interconnected

by bus-bars which received heated current; and

a ground connection and a VHF tapping connection positioned to avoid unstable VHF signal reception.

10. An antenna according to claim 8 wherein the said ground and VHF tapping connection positions are determined by a method according to claims 2 to 7.

11. An antenna substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

12. An antenna for fitting to a vehicle, comprising a sheet of glass for forming a window of the vehicle, a first array of resistive conductors on the sheet interconnected at their ends by bus-bars which receive heater current via respective live and ground connections and have a connecting line from one of the bus-bars for the supply of FM signals, a second array of conductors on the sheet having a connecting line from the same side as the VHF connection to the first array for the supply of an AM radio signal, the connecting line for the supply of FM signals being located adjacent to an end of the

respective bus-bar which is nearer to the second array of conductors.

13. An antenna for fitting to a vehicle, comprising a sheet of glass for forming a window of the vehicle, a first array of resistive conductors on the sheet interconnected at their ends by bus-bar which receive heater current via respective live and ground connections and have a connection on one of the bus bars for the supply of FM radio signals, a second array of conductors on the sheet having a connection for supplying an AM signal, the AM and FM connectors passing on the surface of the sheet of glass to a module thereon which incorporates respective amplifiers and a combiner, a connector leading from the module out of the glass sheet for establishing an RF connection to a radio.

14. An antenna assembly as claimed in claim 13, wherein the module is arranged to receive DC power via the RF connection.

FIG.1.

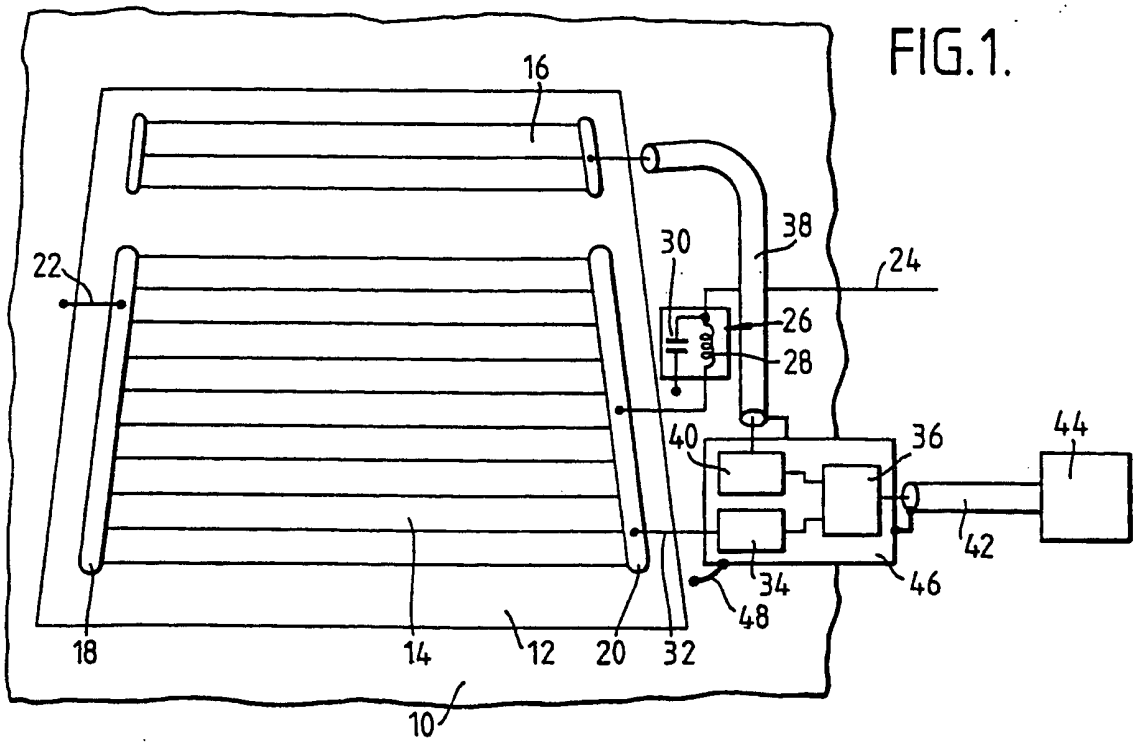
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FIG. 2.

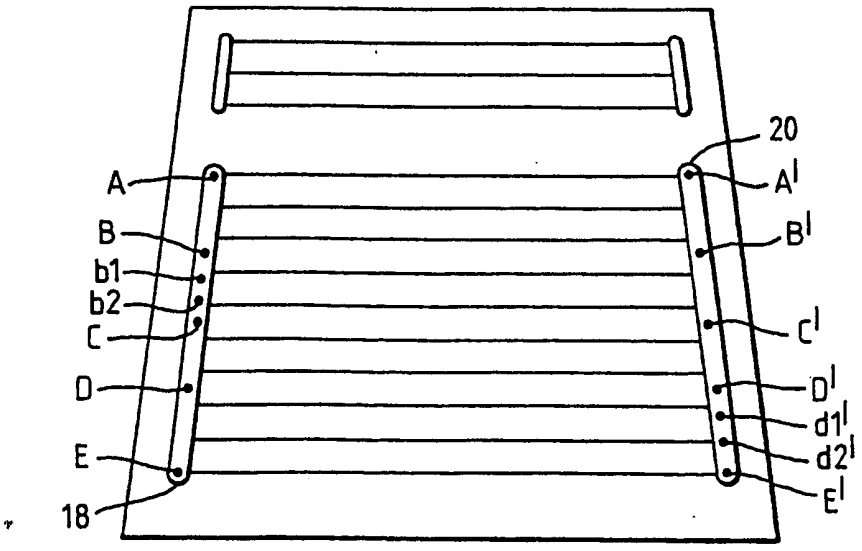
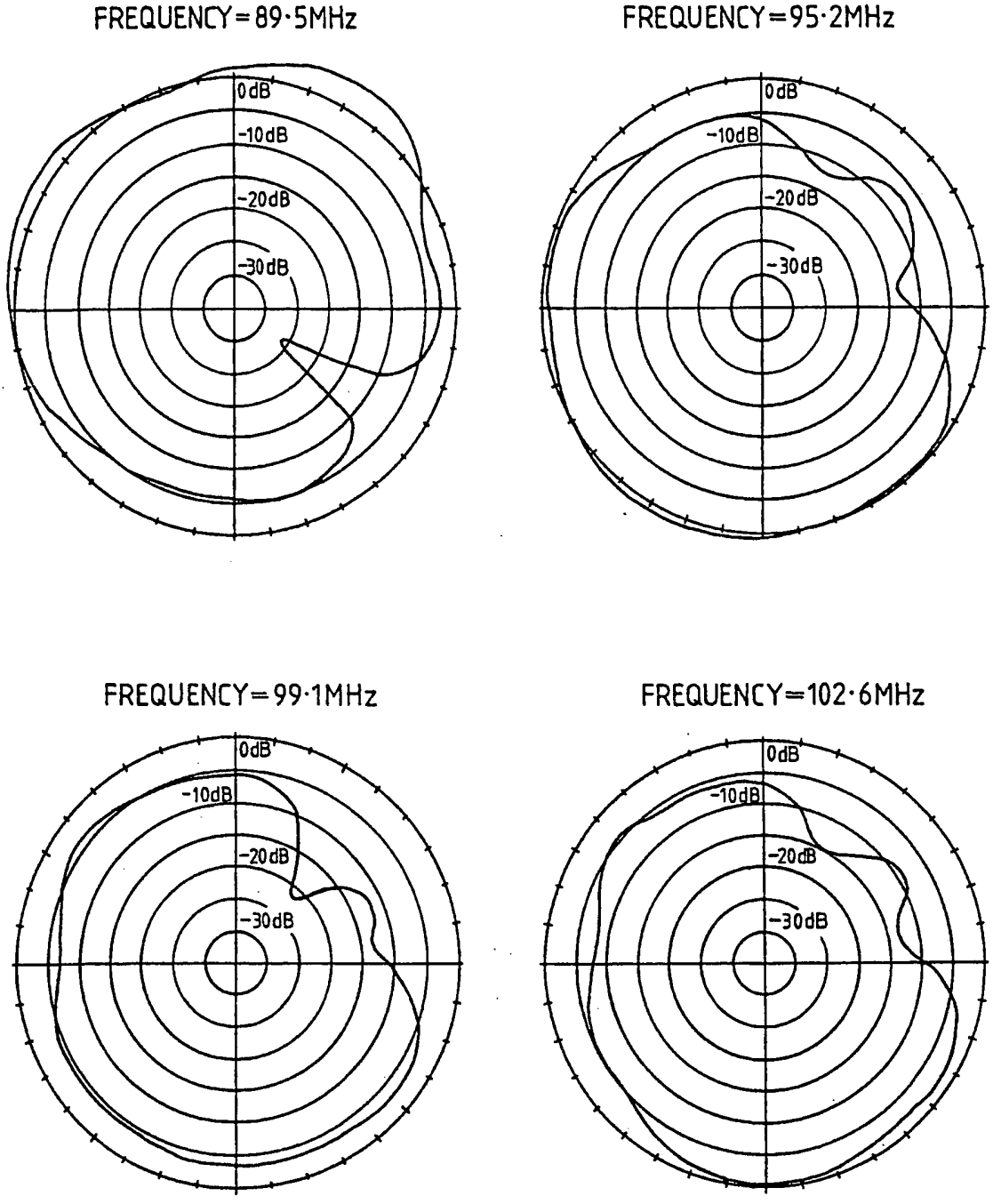
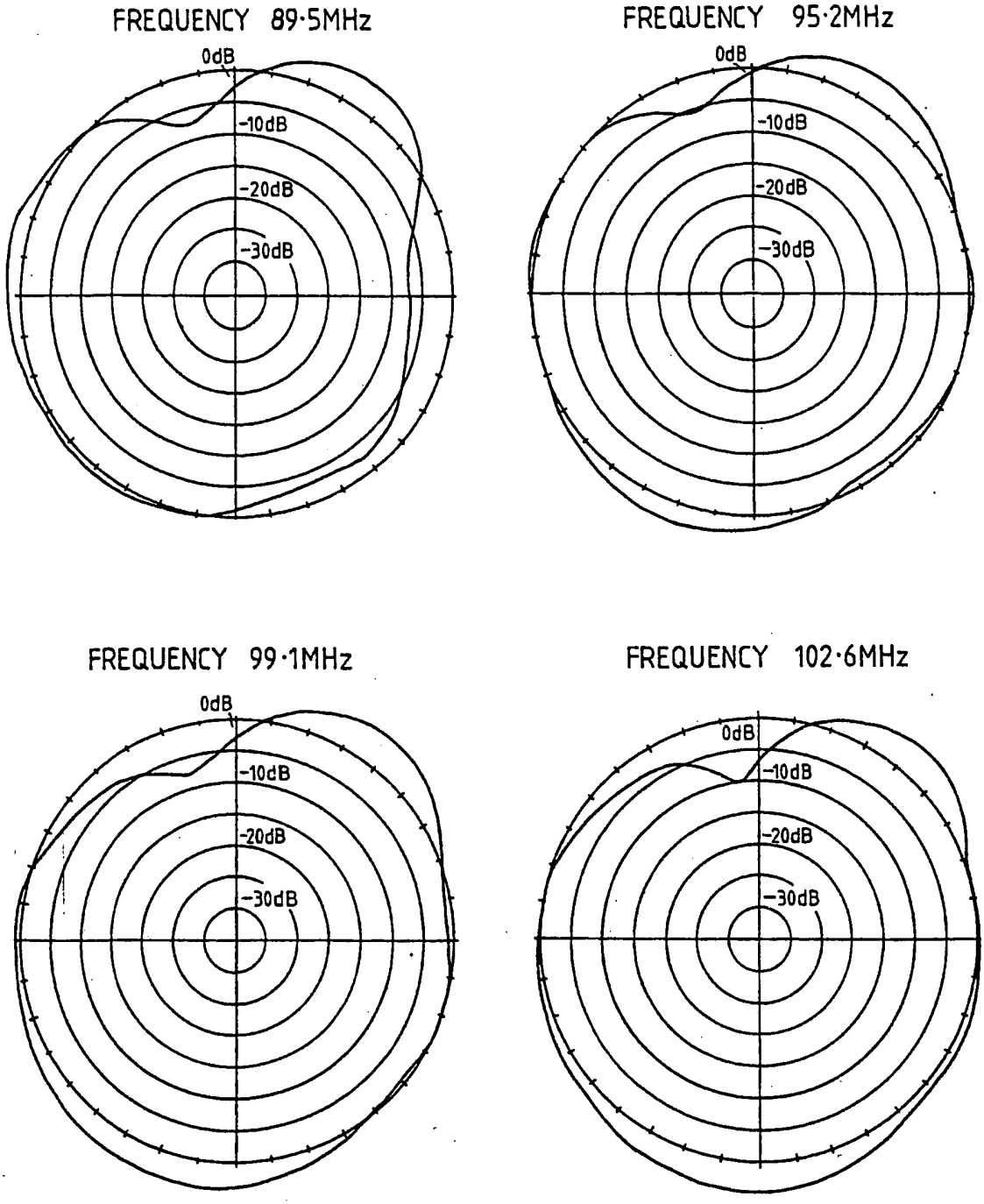

20
A
A'
B
B'
b1
b2
C
C'
D
D'
d1'
d2'
E
E'
18

FIG. 3.



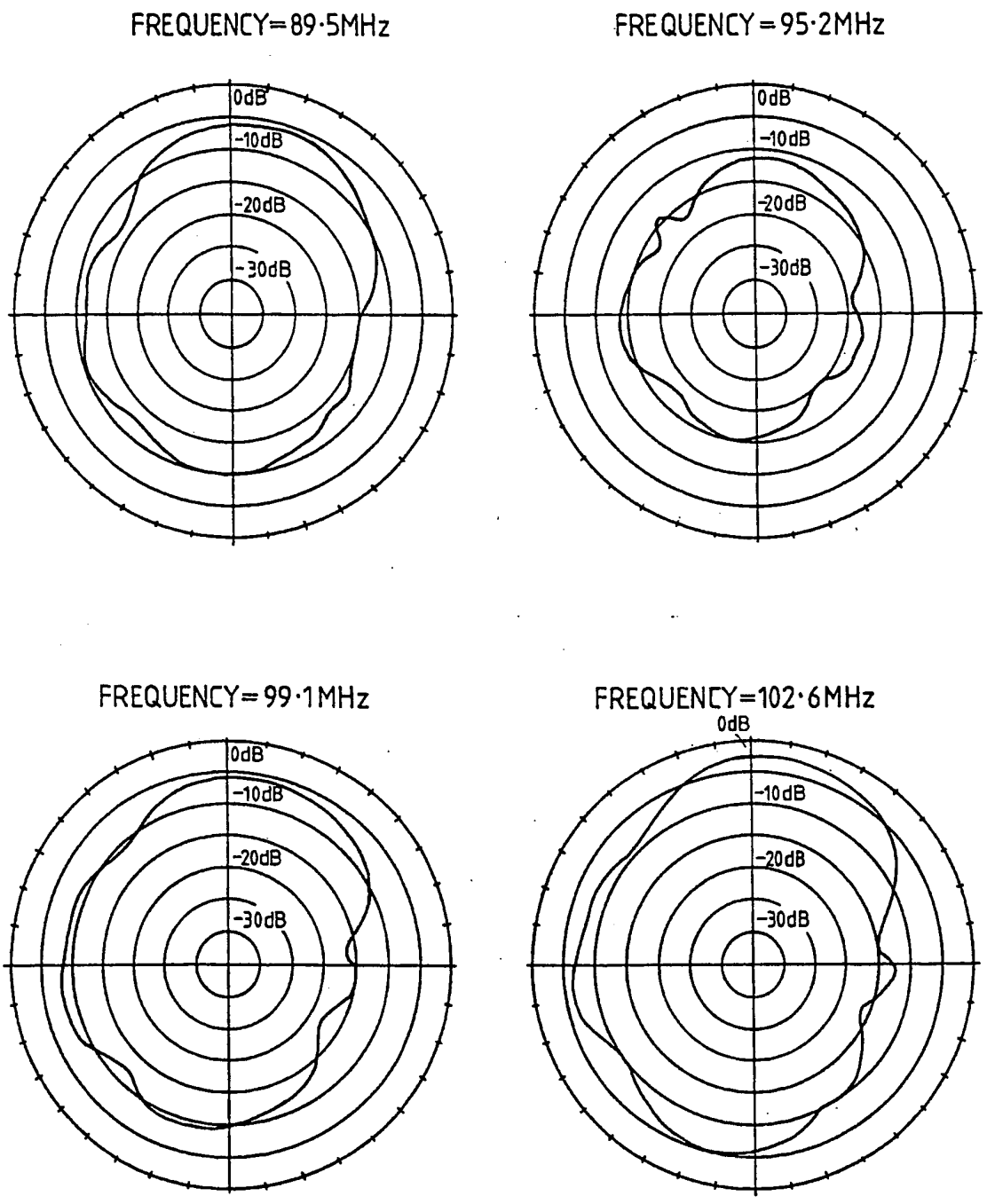
TYPICAL POLAR DIAGRAMS — 'NON-OPTIMISED' CONFIGURATION.

FIG. 4.



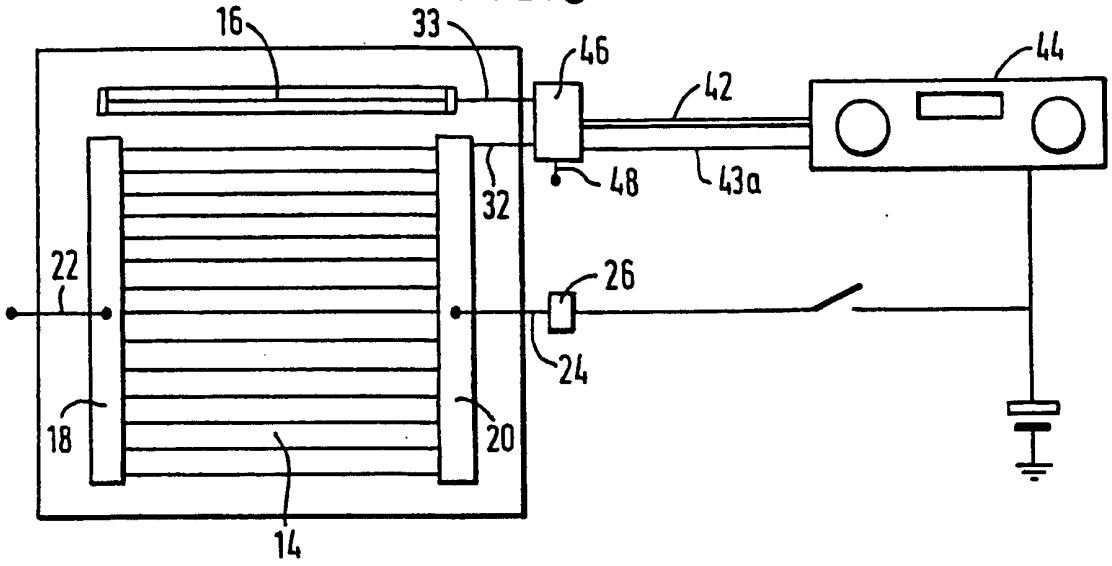
TYPICAL POLAR DIAGRAMS — 'OPTIMISED' CONFIGURATION

FIG.5.



TYPICAL POLAR DIAGRAMS - REAR FENDER MOUNTED VERTICAL ROD

FIG.6.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43a
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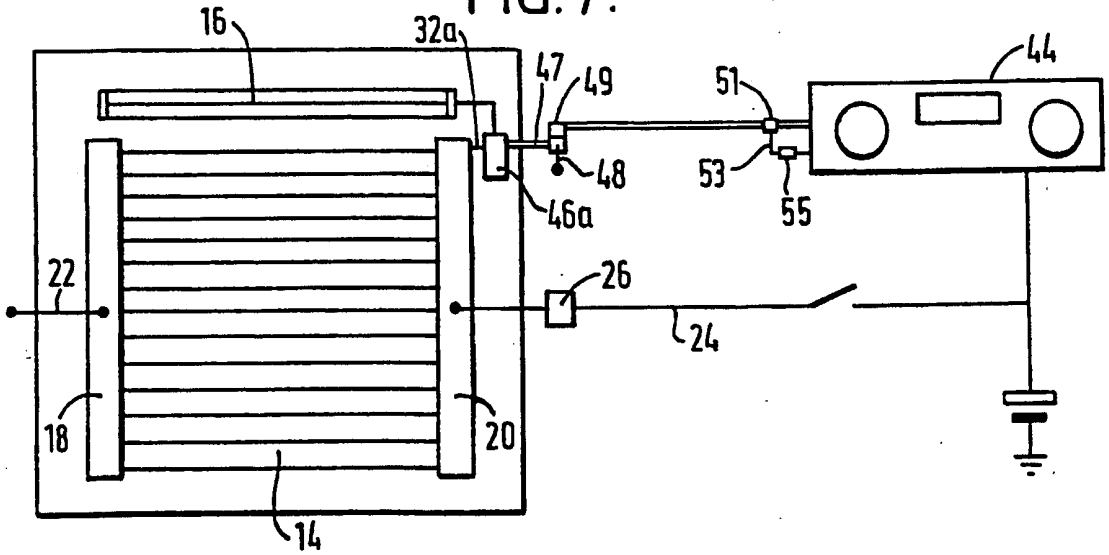
FIG.7.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INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 93/02154

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H01Q1/12

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H01Q G01R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	FR,A,2 601 194 (CENTRAL GLASS) 8 January 1988 see page 10, line 21 - page 11, line 25; figure 6	1-11
A	DE,A,36 18 452 (LINDENMEIER ET AL.) 3 December 1987 see abstract see column 6, line 10 - column 7, line 61; figures 1,8-13	1-11
X	EP,A,0 155 647 (KOLBE) 25 September 1985 see abstract; figure 1	12-14
A	EP,A,0 297 328 (KOLBE) 4 January 1989 see abstract; figures 1-5	12-14

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
26 May 1994	10.06.94

Name and mailing address of the ISA	Authorized officer
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INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 93/02154

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
E	GB,A,2 266 189 (ANTIFERENCE) 20 October 1993 see the whole document	1-11

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inter nal Application No
PCT/GB 93/02154

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